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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 23 December 2002 with an application for Letters Patent number 523360 made by Jacking Systems Ltd.

Dated 7 January 2004.

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523360

Patents Form # 4

NEW ZEALAND

Patents Act 1953

PROVISIONAL SPECIFICATION

Title: Synchronised Lifting System

We, ***Jacking Systems Ltd,***
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Address: *18A Springfield Road, Western Springs, AUCKLAND, New Zealand,*

do hereby declare this invention to be described in the following statement :

FIELD

This invention relates to the lifting of pre-cast concrete slabs and has particular application to a method and apparatus for constructing a multi-storey building.

OBJECT

It is an object of this invention to provide an improved method of lifting pre-cast concrete slabs, or one which will at least provide the public with a useful choice.

STATEMENT OF INVENTION

In one aspect, the invention provides a method of lifting a concrete slab, a plurality of apertures therethrough incorporated and otherwise spread about said slab area, a number of apertures provided with a respect jack, said jack at least comprising a shaft having a portion passing through said aperture and contacting a lower support means, a means for connecting said slab to said shaft, the connection means incorporating at least one supporting member, each supporting member passing through a said aperture and engaging said slab, and a means for effecting longitudinal travel of said supporting means along said shaft, otherwise resulting in the raising or lowering of said slab, position sensors associated with each jack, means for communicating between each jack and one or more main controllers, and means for controlling each jack.

Preferably each aperture therein containing the supporting member is provided in co-operation with the position of the shaft, and henceforth the aperture through which it passes.

Preferably, said lower support means comprises a supporting strut or lower slab.

Preferably each aperture therein containing said shaft is proportionally larger in diameter than said aperture therein containing said supporting member.

Preferably each supporting member engages with the downwardly facing surface of the corresponding slab.

Preferably each shaft comprises a pair of columns on either side of a ball screw, the ball screw being supported by a spherical roller bearing mounted in a top plate, thus bridging the columns.

Preferably the supporting member/s are steel rods adapted to connect said hanger assembly to the slab.

Preferably the supporting member/s are provided with a respect sleeve.

Preferably the supporting member/s are provided with bearing plates on the underside of the slab, and connected by corresponding bearing plates and fasteners to the hanger assembly.

Preferably the connection means comprises a hanger assembly in co-operation with at least one supporting member.

Preferably the hanger assembly is supported for movement along said shaft, and more preferably the hanger assembly is pivotally supported at a point of rotation at some point along the central axis of the ball screw.

BRIEF DESCRIPTION

These and other aspects of this invention, which should be considered in all its novel aspects, will become apparent from the following description, which is given by way of example only with reference to the accompanying drawings in which:

<u>Figure 1</u>: is a schematic drawing showing the relationship of four jacks, and a computer controller.

<u>Figure 2</u>: illustrates a schematic of the variable speed drive attached to each jack.

Figure 3: is a side elevational view of a multi-storey building being constructed in accordance with an embodiment of this invention.

Figure 4: is a side elevational view of one of the jacks, a first-floor slab being lifted.

Figure 5: is a side elevational view showing an additional slab being connected in preparation for raising.

Figure 6: is a side elevational view showing an additional slab being cast in situ.

Figure 7: is a side elevational view showing the raising of the shaft and associated supported strut.

Figure 8: is a side elevational view showing the shaft and associated support strut having been raised and connected.

Example 1

The invention can best be understood by reference to Figures 1 and 2 and the following overview of the system. For simplicity only four jacks 2A - 2D are shown connected to a central computer 5. Each jack is a screw jack driven by an electric motor 3, which is controlled by variable speed drive 4. Typically each motor will be a 0.75 kW, four pole, 50Hz, flange mounted 400 volts, brake motor. Each motor will be driven by a three phase power supply typically 400 volts at 100 amps. Each motor is controlled by a central computer 5.

System Overview

Preferably the system provides a synchronised position control of a number of motors 3. One control parameter is position synchronisation between all the jacks.

Preferably this makes use of variable speed control of the individual jack motors, plus a supervisory layer. The implementation of the controls can be:

a) centralised to a unit located off the jacks, or

b) decentralised such that each jack is intelligent to a degree and the supervisory overhead is reduced.

In either case consideration should be given to the stretch potential of the system. The initial prototype uses a 6 jack system. However, it is preferred that this system can be easily stretched to a 70 jack system.

Connection Hardware

Each Jack 2A - 2B is the building block of the system. It is to be considered a self-contained element that is lifted onto site, connected into power and communications and is ready to operate. Consideration should be given to the outdoor and physical nature of a construction site.

The system is designed so that up to 10 jacks can be daisy chained together; the 10 jacks are to be considered as being connected in series, and not in a ring.

- Jacks are preferably located 15m apart.

- The cabling (not shown) is preferably hardwired at one end, with a plug located on the other end.

- Each jack preferably includes at least one set of sockets (power and communications) for daisy chaining a further jack.

- Expected plug and socket matings over equipment lifetime is 500.

- Connections are preferably weatherproofed to IP65

- Preferably the connectors can be used easily with gloved hands.

Equipment Enclosure on Jack

All local controls, drives, cabling is preferably mounted onto the jack itself, and as much as possible into a single enclosure.

Preferably the equipment is weatherproofed to required standards such as IP65, and all non-IP65 elements are preferably enclosed.

Motor

The motor 3 is preferably a 4pole, 1.1kW, flange mounted, brake motor. Preferably the motor is the only non-IP65 element on the jack. The motor is preferably mounted shaft down.

Preferably an encoder is mounted on the motor. The encoder is preferably physically protected from damage; e.g. being stood on.

Variable Speed Drive

Preferably torque monitoring of the motor is provided.

During the initial portion of the lift, after placement through the slab all jacks are driven until a pre-set torque is obtained (or a threshold distance is exceeded). This takes up an initial load.; pre-tensioning.

Preferably the jacks have an overload rating of at least 150%. Although during the course of active lifting it is not envisaged that the jacks will operate in overload.

For the purposes of fault detection, the drive is preferably capable of being halted when a torque threshold is exceeded. This is to guard against events like driving into the ends of the ball screw, jamming of the load being lifted and the like.

There is an occasional requirement for the lowering of the load. Preferably the gearbox and ball screw have efficiencies of better than 90%. Regeneration capability is to be included. Optionally if regeneration resistors are integral to the drive, then a rating provided for the lowering ability given the drive is preferably housed in an IP65 enclosure; the lowering requirement will either be a short distance (say 50mm @ 1mm/sec) for final alignment or full lowering of the load (say 4.5m @ 1mm/sec). Alternatively the regeneration resistors can be mounted externally.

Preferably the motor's brake is controlled; more preferably the motor torque is verified before the brake is released.

Other inputs to the drive can include:

- Upper limit switch
- Lower limit switch
- Emergency stop

Each of these inputs is to be considered as a set of clean contacts, and when opened the drive is to stop instantly (not drive to a halt). The status of these inputs, especially when tripped, is to be reported to the central controller.

Preferably the simplest cable installation is that the communications cable and the input power cable which daisy chain between jacks are strapped together. Preferably the effect of

electrical noise on the power cable is minimised such that any degradation in communications performance does not occur.

System Controller

Preferably the System Controller includes:

1. An enclosure which provides
   - a 230V outlet for a computer
   - an emergency stop pushbutton. The emergency stop push-button shall disable power to the system.
   - A communications link to the laptop
2. A laptop operating a MMI package, from where the operator will operate the system.
3. Optionally, a PLC controller can be incorporated.

System Controller MMI Component

1. The nature of the MMI is to provide the supervisory and control level.
2. Preferably the minimum operator inputs includes:
   - set the direction (up/down),
   - set the distance to traverse (in mm),
   - set any maximum speed (mm/sec) and torque (%) limitations.

3. The MMI is preferably laptop based, and running under Windows 95 or NT, or other suitable operating system.

4. During the lift, all torque and position information recorded from the field is preferably time stamped and recorded to disk. This information is preferably saved in a tab-delimited fashion, such that it can be read into Microsoft Excel with no further modification.

5. For each jack, a database of life load / hours run is preferably automatically maintained.

6. Preferably the replacement of a jack, due to failure say, should be task largely performed under MMI control with all setting and current position information downloaded across the communication link from the MMI to the drive when it is connected in.

7. Preferably for an out of tolerance condition, the system is to be driven to a halt and a warning reported.

8. Preferably the information from the field is to be presented on the laptop screen such that exceptions are easily visible; something similar to green ... orange... red signal level displays which draw attention to the relevant points only.

9. Preferably warnings are provided to the operator, indicating the nature of the problem and possible help. The nature of the situation will determine the timeframe in which either the system responds or awaits operator input; e.g. an out of tolerance results in the system being driven to a halt. Error and Warning conditions displayed on the MMI, and logged to file with a time stamp, can include:

- Out of position tolerance, plus an indication of which jacks are in error
- Overload of jacks

- Jack infringing a limit switch, upper or lower
- Jack infringing a torque limit (driven into the end stops say)
- Any drive error or warning that warrants operator attention
- Lost communications with a jack or item of equipment on the communication network.
- The provision of the total current drawn by the system (derived from drives). This may allow reduced speed operation from a supply rated less than that required to lift at full speed.

System Wide Points

a) Preferably the positional accuracy between two jacks over the duration of the lift is 0.5 mm. The lift range is preferably 5.5m and the time to traverse this distance is preferably a minimum of 60 minutes. Preferably the maximum number of jacks will be 70.

b) Preferably provision is made for faster traversals, e.g. when driving the jacks unloaded from one end to the other.

c) The primary task is to lift a slab and any associated catch screens or formwork, such that the slab is maintained level over the duration of the lift. A simple extension which does have occasional use is the ability to raise a slab onto a defined angle.

d) Preferably electrical noise suppression is provided.

e) Preferably the ambient temperature range for operation is 0°C to +50°C.

f) It is expected that the load experienced by each jack will be different.

Figures 3-8

In order to understand how the control system will operate, the following will now describe the use of the above jack on the construction of a multi-storey building with reference to Figures 3-8. This will provide an overview of the mechanical operation of a first type of jack, but the description of the control system in Figures 1 and 2 has been omitted from this 'mechanical description'.

As shown in figure 3, there exists a ground floor slab 5, on to which a concrete slab 20 is formed with a plurality of apertures (not labelled) therethrough. A number of shafts 12 are positioned through said apertures and contacting said ground floor slab 5. Boxing 6 is provided in preparation for the pouring of an additional slab in co-operation with preparation for the lifting of the slab 20, as the following will further explain.

As shown in figure 4, preferably a gearbox/motor/drive assembly 8 is axially positioned at the top of each shaft 12 to drive the ball screw 9 to raise or lower a hanger assembly 15 with respect to the shaft 12 and hence raise or lower the slab 20 relative to the lower floor slab 5.

Preferably, once said slab 20 has been raised the required floor to ceiling height, for example 3 metres, the slab is then lowered approximately one slab thickness, so as to ensure the final floor to ceiling height does not gain a height of one slab thickness, after each slab is raised.

As figure 5 shows, once the slab 20 has been raised to the desired position, and additional slab 22 poured, a connection means 30 is then disconnected from the slab 20 and re-engaged with uppermost slab 22.

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Preferably, the foot portion 35 is proportionally sized in relation to the respective aperture through which it passes (aperture 40 in this case), so as to facilitate the retraction of the foot 35 through the corresponding aperture 40.

Once retraction and subsequent reengagement of said shaft 12 and re-engagement with, for example, the uppermost slab 22 has been actuated, said slab is then prepared for the pouring of an additional slab 24, for example, by way of boxing 6, the connection means is engaged with newly poured slab 24, and the subsequent raising of said slab 24 (not illustrated).

It should be noted that the present invention allows lifting of the various slabs prior to full curing of the slabs. Once a slab is in position, temporary support structures or back props 50 support and stabilise the slab while it fully cures. During this curing stage, it is possible to connect the slab 20 to the remainder of the building. This connection with structural walls or columns of the building may be accomplished by means of connection plates or reinforcing steel extending from both the wall or column and the slab, this reinforcing steel overlapping in a previously formed void. The connection is then accomplished by filling the void with a hardenable material, such as concrete.

Another method of attaching the slab to the building is to use structural beams which are connected to the wall of the floor below. To explain, a slab is lifted to a position slightly higher than the final floor to ceiling height. Structural beams are then positioned by any appropriate means for example small electric forklifts, and connected to the various walls. The slab is then lowered and connected to the structural beams. Such a method of attaching the slab to the building is safer and speedier than conventional methods of construction and allows all work to be carried out on a stable platform.

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As shown in figure 7, said retraction of said shaft 12 is accompanied by the raising of strut supports 32, thereby providing effective engagement of jack with, for example, lower slab 22, as shown in figure 8.

As it will be clear to a person skilled in the art, the above sequence can be further repeated for the number of storeys required in the building. The sequence of events may be summarised as, firstly pour a slab about the prop means, and cure to 22 millipascals, prepare for the pouring of the second slab, raise slab and associated preparation means, disengage connection means from newly raised slab, pour uppermost slab, engage connection means with uppermost, newly poured slab, raise shafts, position support struts, engage struts with corresponding shaft/s, raise uppermost slab, repeat process. It should be noted that since the jack climbs the building with each newly constructed floor, there is no need to remove and re-position scaffolding from floor to floor.

ADVANTAGES

The present invention provides an inventive method and apparatus for constructing a multi-storey building. The inventive method and apparatus lifts an entire floor slab or sections of a floor slab into position without the need for exterior lifting apparatus such as cranes. There is also no need for repositioning of scaffolding, form-work etc. from one floor to the next since the inventive prop means climb the building as it is constructed ready to lift the next floor slab.

While the present inventive apparatus may be used for any building with at least ground and first floor levels, it is envisaged that the inventive method and apparatus will provide the greatest benefits in large multi-storey buildings with approximately six or more floors.

The control system of this invention enables the controlled lifting of cast concrete floors, without the need for external cranes or the like, as each floor can be cast upon the floor below, and provided with suitable apertures to allow the jacks to be inserted through those

apertures, and to effectively climb up the building as the slabs are raised into position, as shown in the overview with respect to Figures 3-8.

The control system has the particular advantage in providing safe, smooth, controlled lifting such that the floor slabs can be raised substantially horizontally, and can be lifted together with any associated catch screens, edge form-work, or other ancillary structure or fittings located on or attached to the floor slab.

The invention lends itself to the construction of floor slabs of various plate sizes, and it is envisaged that a small operation may use six jacks operating in unison, but much larger multi-storey buildings with substantial floor plates may use up to 70 jacks at a time.

The jacks, are robust, and can be readily installed or removed from site to site.

VARIATIONS

The control system is illustrated as being controlled by a laptop or portable computer, but it is possible that it could be controlled in a number of different ways either using specialist hardware, or off-the-shelf computers, and indeed the system could be controlled from off-site provided there is a suitable connection between the sensors and controllers on the jacks, perhaps via the Internet, to a specified computer. However, for most purposes it is preferred that the controller is on-site, and is available to an operator who can watch the operation of the jacks, as well as monitoring the computer screen and other readouts. In most cases the operator will position the portable computer in a cabin, caravan or the like on the site adjacent the building being constructed, although it is possible that the operator and the control computer could be located on the slab being lifted, although this is less preferable.

Finally, it will be appreciated that various other alterations may be made to the foregoing without departing from the spirit or scope of this invention.

PIPERS
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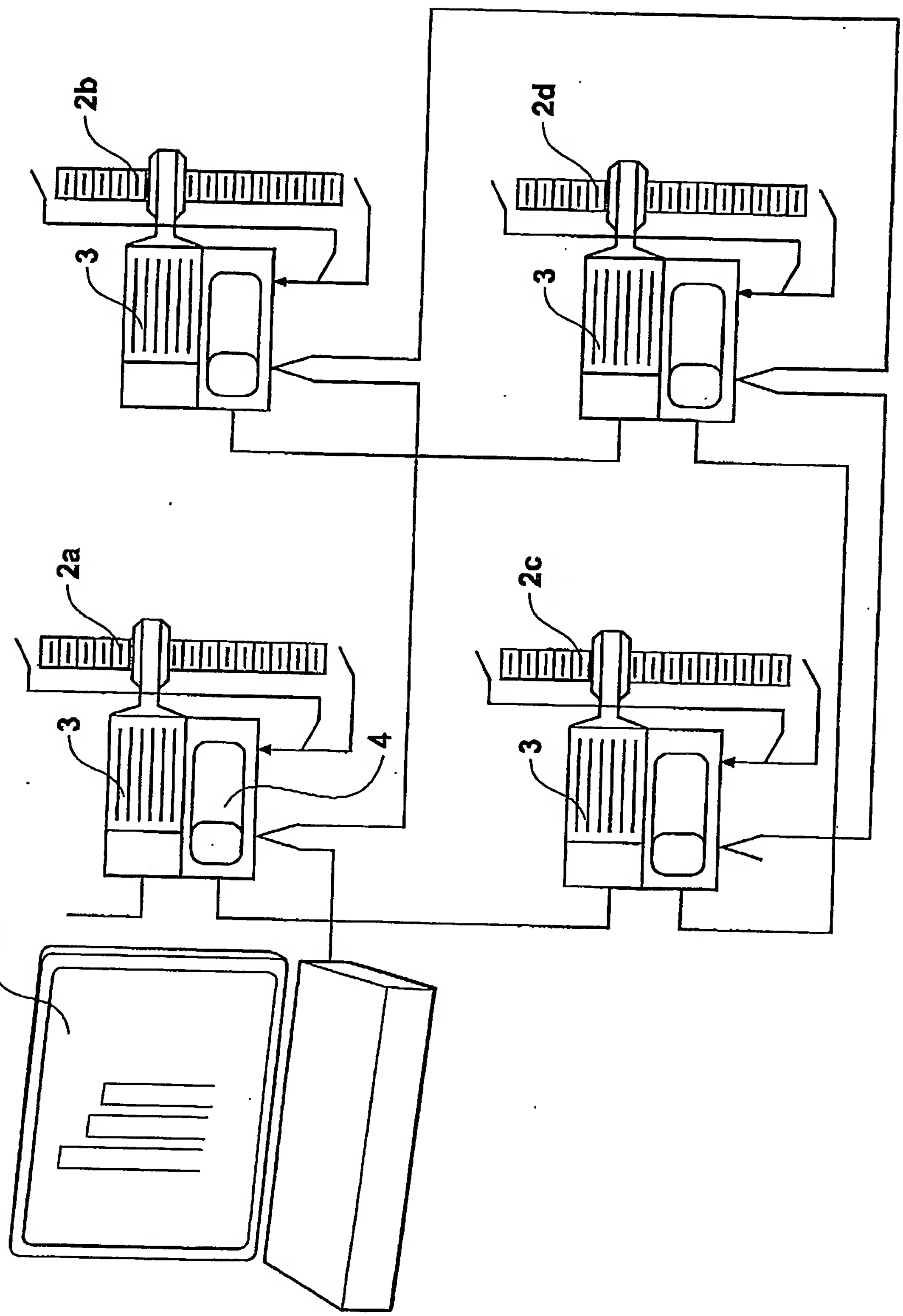

FIG. 1

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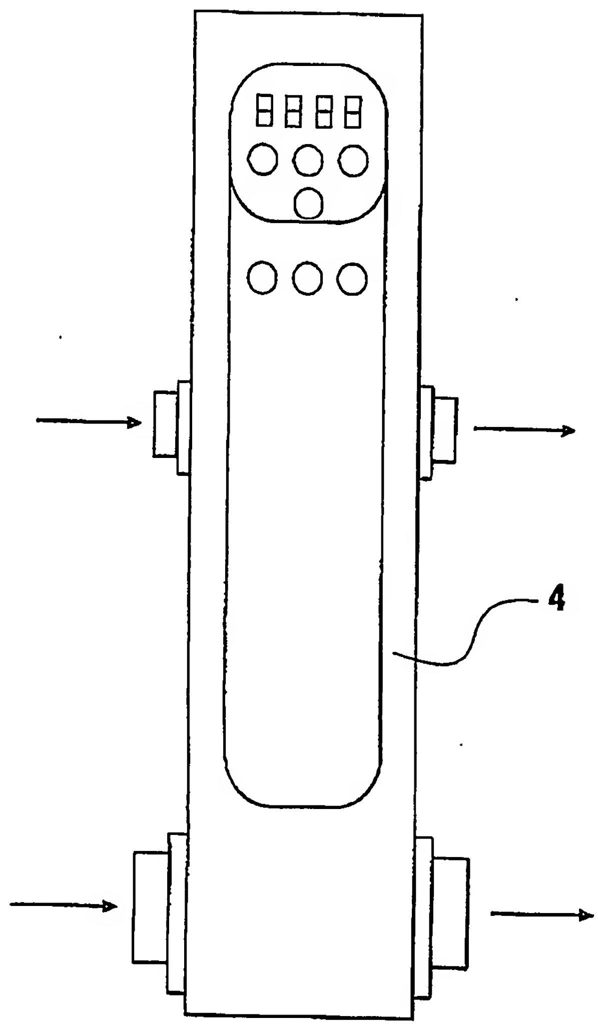

FIG. 2

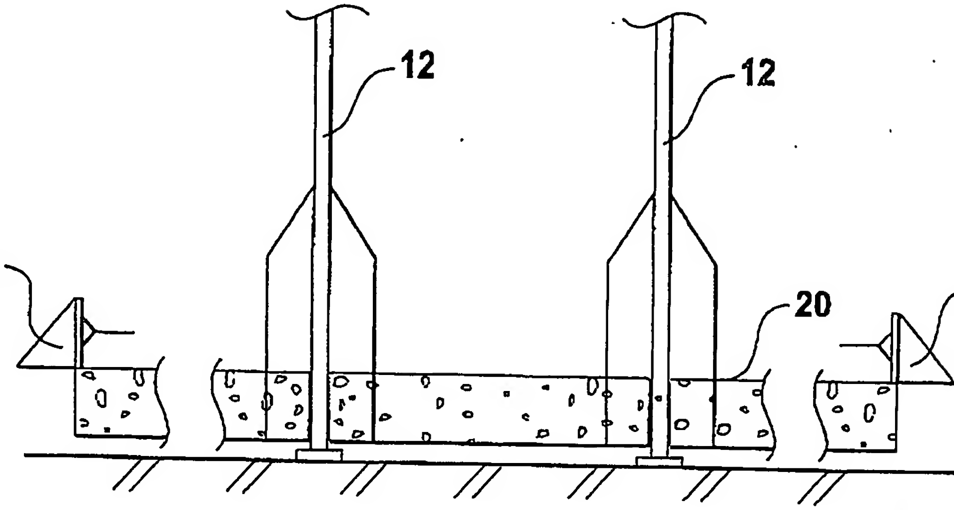

FIG. 3

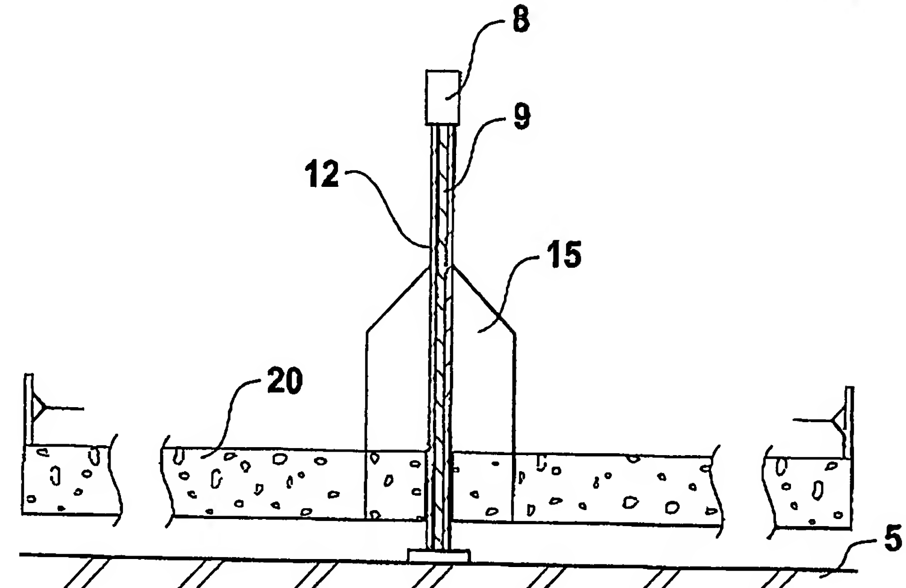

FIG. 4

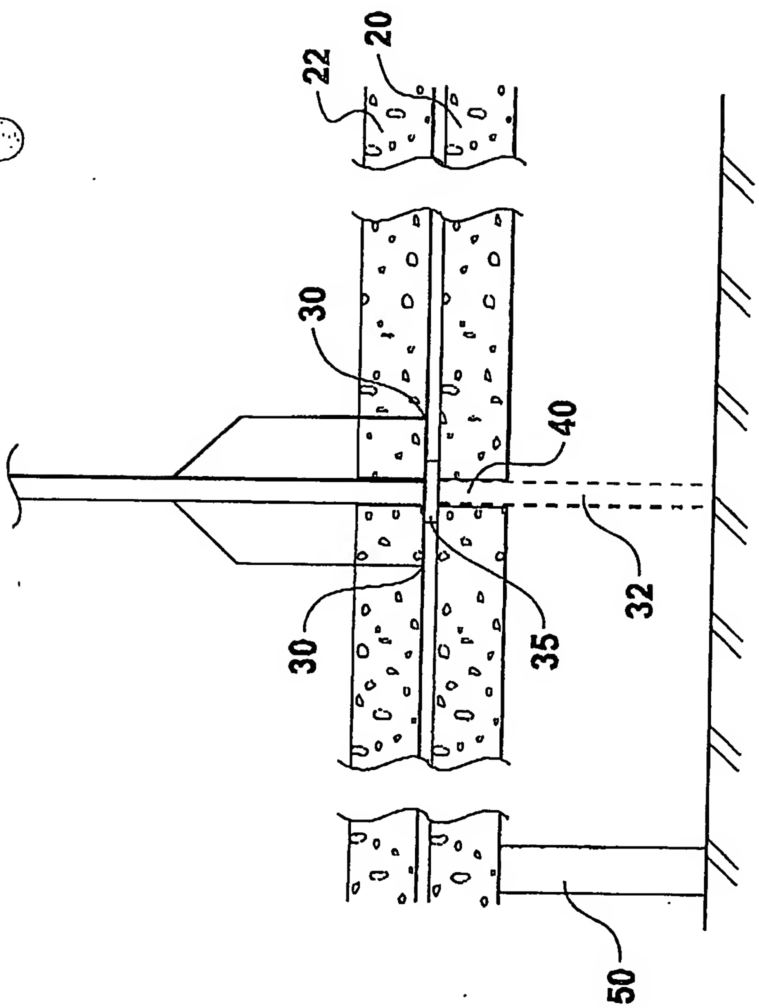

FIG. 5

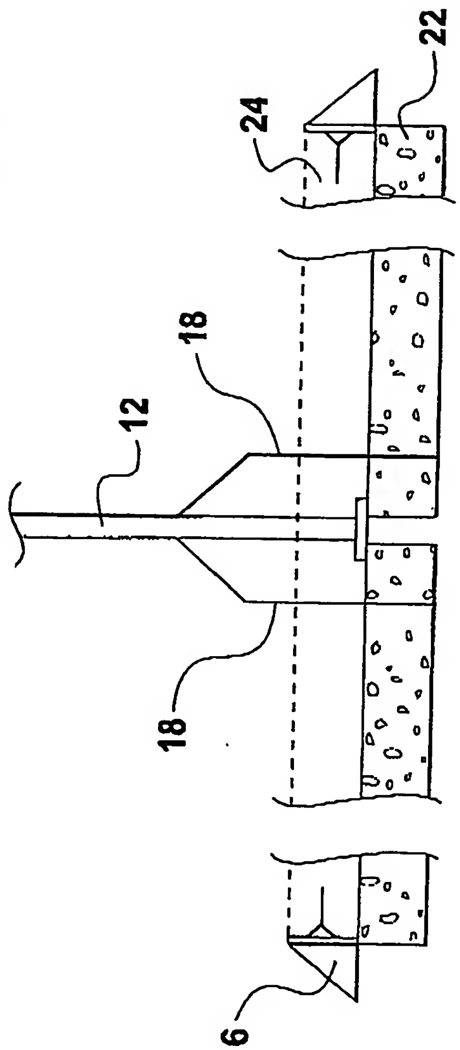

FIG. 6

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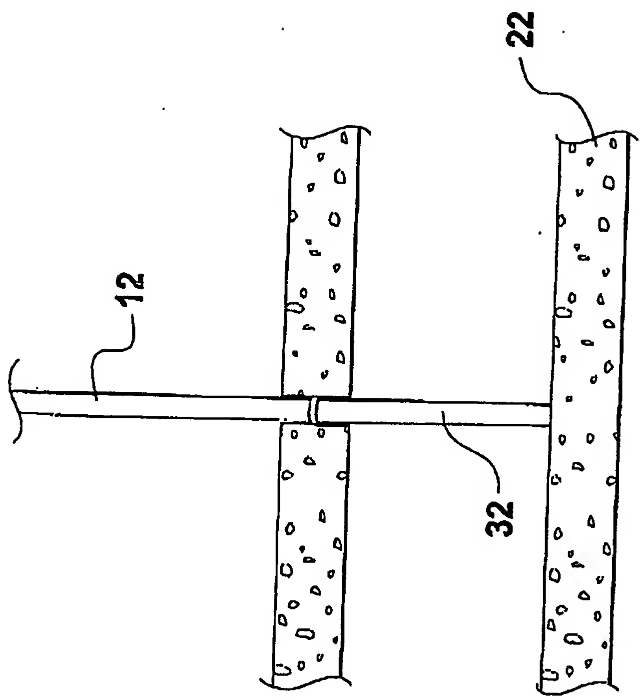

FIG. 8

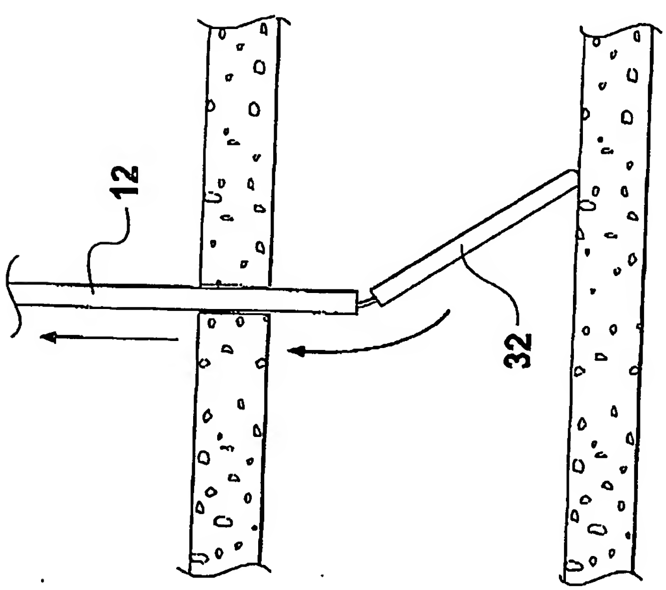

FIG. 7